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Creep of die-cast MRI230D Mg alloy

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Abstract

MRI230D is a magnesium alloy containing Ca as one of the primary alloying element to enhance the creep resistance by forming C36 intermetallic lamellar phase along the grain boundaries. Creep behavior of MRI230D alloy was investigated using the impression creep technique. The tests were carried under constant temperature (423 – 513K) and constant stress (60 – 80MPa) by impressing a cylindrical punch on the specimen. From the microstructure and XRD pattern results of as-cast and after creep test specimens observed that the creep resistance of the alloy is mainly due to the increased volume fraction of C36 phase along grain boundaries.

Keywords: Magnesium alloy; MRI230D; creep; Microstructure; precipitation

1. Introduction

The magnesium alloys are mainly used in the applications of automobiles, structural components because of its low density, high specific weight ratio, etc. But the only problem with it is its low creep resistance at high temperature. AZ91 is the most commercialized magnesium alloy. However its application is limited because of its poor creep resistance at temperatures of more than 393K [1]. For this MRI230D casting alloy was developed. Addition of Ca causes the

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formation of intermetallic compounds such as ((Mg, Al)$_2$Ca) which possess high thermal stability and tends to precipitate at the grain boundaries [2-3]. MRI230D alloy has high creep resistance up to 200^{o}C with loadings of 80-110MPa. So the present investigation on MRI230D alloys will help to know the creep behavior and rate controlling mechanism involved during impression creep test.

2. Experimental procedure

MRI230D alloy which was used in this study is having a chemical composition as shown in table 1.The specimen for the impression creep test dimensions are 10×10×10 mm^3. The impression creeps test was performed by impressing 2mm diameter flat ended cylindrical punch on the surface of the sample.

Table. 1. Chemical composition of the MRI230D alloy in wt. %.

Alloy	Mg	Al	Ca	Mn	Sr	Zn	Sn
MRI230D	Balance	6.45	2.25	0.27	0.25	<0.01	0.84

The XRD analysis was done by using CuKα (λ=1.5418A°) radiation. Microstructural investigation of both the specimen was carried out by using Optical microscope and Scanning electron microscope.

3. Results and discussion

3.1 Microstructural investigation of as-cast and creep tested specimen

The XRD patterns obtained from the as-cast MRI230D specimen is shown in Fig.1 respectively. The XRD pattern of the as-cast shows that the alloy consists of primary α-Mg peak and the peak corresponding to C36 ((Mg, Al)$_2$Ca) phase. The optical micrograph image of the MRI230D alloy in both the as-cast and creep tested condition are shown in Fig.2 (a&b). The secondary electron scattered micrographs obtained using SEM in the as-cast specimen is shown in Fig.3.

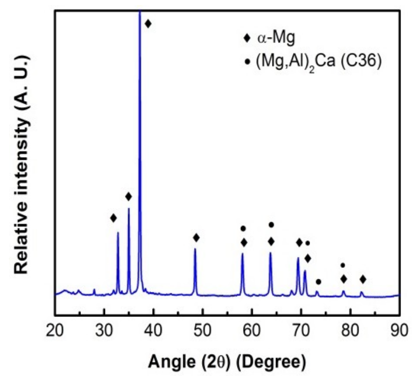

Fig. 1. XRD patterns of the MRI230D alloys in as-cast conditions.

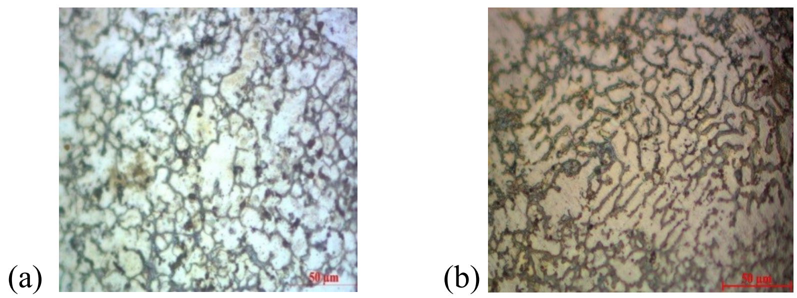

Fig. 2. Optical images of the MRI230D alloys in both a) as-cast b) creep tested conditions.

3.2 Nature of creep behavior

Fig.3.(a & b) shows the typical creep curves of MRI230D alloy under different constant temperatures (150^{o}C to 175^{o}C) and under different constant stresses (60-120 MPa). These graphs contain only the primary and steady state creep regions in the creep curves and no tertiary region is present.

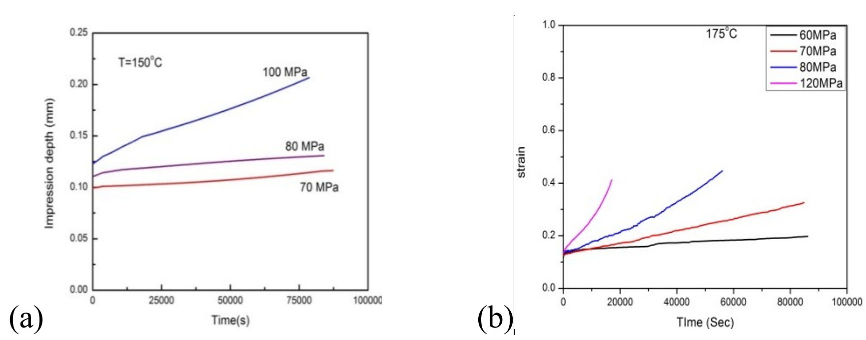

Fig. 3. Strain vs Time curves of MRI230D alloy tested at a) 150^{o}C b) 175^{o}C.

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Fig. 4 shows the microstructure of the MRI230D alloy beneath the indenter after impression creep test at 448 K and σ_{imp}=120MPa. In region 2, the C36 phase were elongated and aligned in the direction of flow of material as shown with arrow head while in region 1 and 3,no microstructural changes were detectable.

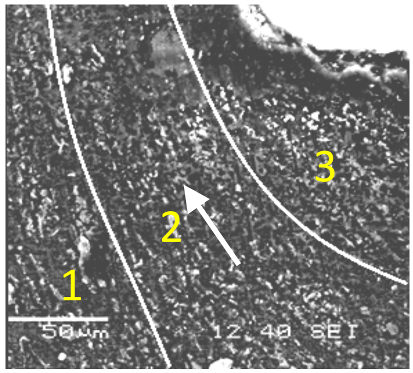

Fig. 4. SEM microstructure of the MRI230D alloy after creep test.

4. Conclusion

MRI230D alloy consists of α (Mg) matrix phase as well as the secondary eutectic C36 ($(Mg,Al)_2Ca$) phase and an Al-Mn-rich phase. MRI230D alloy shows creep resistance up to 175°C under loading of 80-100 MPa, so it can be used in Powertrain applications. The better creep resistance of the MRI230D alloy was mainly attributed to the finer and denser network of higher volume fraction of the eutectic C36 phase present along the grain boundaries and triple points in α-Mg matrix hindering dislocation movement during creep deformation.

References

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